PB86-110939

Evaluation of Fabric Filter Performance at Ames Solid Waste Recovery System

PEDCo-Environmental, Inc., Cincinnati, OH

Prepared for

Environmental Protection Agency
Cincinnati, OH

Oct 85

U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-110939

EPA/600/2-85/120
October 1985

EVALUATION OF FABRIC FILTER PERFORMANCE AT AMES SOLID WASTE RECOVERY SYSTEM

by

Fred D. Hall, John M. Bruck, Dione N. Albrinck
PEDCo Environmental, Inc.
Cincinnati, Ohio 45246

Contract No.68-03-2509

Project Officers

Michael I. Black
and
Robert A. Olexsey
Alternative Technologies Division
Hazardous Waste Engineering Research Laboratory
Cincinnati, Ohio 45268

HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U. S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/2-85/120	2.
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE EVALUATION OF FABRIC FILTER PERFORMANCE AT AMES SOLID WASTE RECOVERY SYSTEM	5. REPORT DATE October 1985 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) F.D. Hall, J.M. Bruck, D.N. Albrinck	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDco, Inc. Cincinati, Ohio 45246	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-03-2509
12. SPONSORING AGENCY NAME AND ADDRESS Hazardous Waste Engineering Research Laboratory Office of Research and Development U.S. EPA Cincinnati, OH 45268	13. TYPE OF REPORT AND PERIOD COVERED Project Report 10/78-11/79 14. SPONSORING AGENCY CODE EPA/600/12

15. SUPPLEMENTARY NOTES
Michael Black, P.O.; Robert A. Olexsey P.O. 569-7717

16. ABSTRACT

This project report evaluates the particulate control system at the Ames Solid Waste Recovery Plant. The main output of the Ames resource recovery is refuse-derived fuel (RDF), which is transported to an adjacent power plant for burning and subsequent generation of power. A fabric filter was installed to control dust from the shredders, air density separator (ADS), and conveyor transfer points. This report describes the processing plant and the efficiency of the fabric filter equipment.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED 20. SECURITY CLASS (This page) UNCLASSIFIED	21. NO. OF PAGES 46 22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of solid and hazardous wastes. These materials, if improperly dealt with, can threaten both public health and the environment. Abandoned waste sites and accidental releases of toxic and hazardous substances to the environment also have important environmental and public health implications. The Hazardous Waste Engineering Research Laboratory assists in providing an authoritative and defensible engineering basis for assessing and solving these problems. Its products support the policies, programs and regulations of the Environmental Protection Agency, the permitting and other responsibilities of State and local governments and the needs of both large and small businesses in handling their wastes responsibly and economically.

This project report discusses the Ames Solid Waste Recovery Plant. This plant processes *refuse* into refuse-derived fuel (RDF). This research test was conducted on a fabric filter that was installed to control particulates from the shredders, air density separator, and conveyor transfer points.

The information contained herein will be of interest to those designers or users who are contemplating or working with a system similar to the Ames system. Requests for further information regarding the production and utilization of refuse-derived fuel should be directed to the Thermal Destruction Branch, HWERL, Cincinnati.

David G. Stephan, Director
Hazardous Waste Engineering Research Laboratory

ABSTRACT

This research report evaluates the particulate control system at the Ames Solid Waste Recovery Plant. The main output of the Ames resource recovery is refuse-derived fuel (RDF), which is transported to an adjacent power plant for burning and subsequent generation of power. A fabric filter was installed to control dust from the shredders, air density separator (ADS), and conveyor transfer points. This report describes the processing plant and the efficiency of the fabric filter.

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SECTION 1

INTRODUCTION

Recovering energy or valuable materials from municipal solid waste (MSW) is increasingly important as the limitations of U.S. energy resources become more evident. Although the composition of municipal refuse varies widely with consumer habits, types of local industry, geographic location, time of year, and numerous other factors, about 75 percent of the solid waste collected is combustible. Generating energy from waste materials is not totally advantageous, however, unless the recovery processes cause no significant degradation of environmental quality. Operators of resource recovery facilities therefore should plan to apply the most effective of the available technologies for control of potentially harmful air emissions.

The nature and magnitude of atmospheric pollutant emissions caused by resource recovery and by thermal conversion of waste to energy are not yet well defined. Thus far, several types of pollutants have been identified in air emissions from various waste-to-energy operations. These include particulates, heavy metals, bacteria, chlorides, sulfur oxides (SO_x), nitrogen oxides (NO_x), and polycyclic organic matter (POM).

This report evaluates the particulate control achieved by the fabric filter at Ames Solid Waste Recovery System, a resource

recovery plant operated by the municipal Department of Public Works of Ames, Iowa. PEDCo Environmental, Inc., tested and assessed the fabric filter for the U.S. Environmental Protection Agency (EPA) as part of a 36-month EPA study of air pollution emissions and control technologies for waste-as-fuel processes.

The major output of the Ames resource recovery plant is refuse-derived fuel (RDF), which is transported to an adjacent power plant for burning and subsequent generation of power. Before late 1978, the processing plant operated without control of in-plant particulate-laden air. A fabric filter, however, was installed to control dust from the shredders, air density separator (ADS), and conveyor transfer points. To date, the fabric filter has operated successfully, with a noticeable reduction in in-plant air dust concentrations.

After a brief summary and conclusions, the report describes the solid waste processing plant and fabric filter equipment, reviews the test plan, and discusses results and recommendations.

SECTION 2

SUMMARY AND CONCLUSIONS

PEDCo tested particulate concentrations in the inlet and outlet gas streams of the fabric filter operating at the Ames resource recovery facility. These tests were conducted on July 17 and 18, 1979, under contract to the Hazardous Waste Engineering Research Laboratory (HWERL) of the EPA. The objectives were to determine particulate collection efficiency of the fabric filter and to quantify inlet and outlet particulate concentrations.

Over the 2-day test period, four simultaneous inlet-outlet test runs were completed. The inlet sample was obtained by EPA Method 5. The outlet sample was obtained by simultaneously traversing the "open-air" top of the fabric filter with two high-volume (hi-vol) samplers, along two separate straight traverses. The particulate concentrations found along each outlet traverse were averaged to obtain the outlet particulate concentration for each run.

Table 2-1 summarizes the fabric filter performance during the four test runs. Calculations of average inlet and outlet particulate concentrations were based only on the values from the first three test runs because a sampling error occured during Test

TABLE 2-1. SUMMARY OF FABRIC FILTER PERFORMANCE

Test run No.	Inlet particulate concentration, mg/dry std. m^3	Outlet particulate concentration,[a] mg/dry std. m^3	Particulate removal efficiency, %
B-1	748	11.4	98.5
B-2	259	8.63	96.7
B-3	331	9.16	97.2
B-4	[b]	18.6	[c]
Average	446[d]	9.73[d]	97.8[d]

[a] Average of two outlet samples per run.

[b] Inaccurate value because of sampling error.

[c] Not calculated because of sampling error.

[d] Not including Test Run B-4.

Run B-4. The outlet concentration measured during Test Run B-4 is reported as an individual value; because there is no corresponding inlet value, it is not used in calculating the efficiency of collection. Excluding Test Run B-4, the average particulate removal efficiency was 97.8 percent.

Experimental results indicate that the fabric filter effectively controls particulates generated by various sources in the Ames resource recovery plant. The fabric filter was tested and evaluated under normal operating conditions; no attempt was made to optimize the operation or collection efficiency of the unit.

SECTION 3

FACILITIES AND EQUIPMENT

Refuse is delivered to the Ames resource recovery plant by trucks and by residents 5 days a week, during normal business hours. Trucks are generally weighed before unloading onto the tipping floor. Discarded "white goods" (refrigerators, washing machines, etc.) and other bulky items are removed and placed in a large dumpster for landfilling. A front-end loader is used to push other waste into the feed hopper of the primary shredder, which is the first unit operation of the recovery process.

The Ames plant undergoes frequent modifications to improve equipment operation, RDF characteristics, and environmental conditions, such as in-plant air quality. The test runs discussed in this report were performed 2 days after plant startup following process downtime. The plant was brought back on line smoothly and operated at approximately 150 tons per eight-hour day during each day of testing. Figure 3-1 is a flow diagram of those steps in the resource recovery process from which dirty air is sent to the fabric filter.

Because dusting at several unit operations in the plant presented problems, the fabric filter was installed. Technical specifications for the fabric filter are presented in Appendix A.

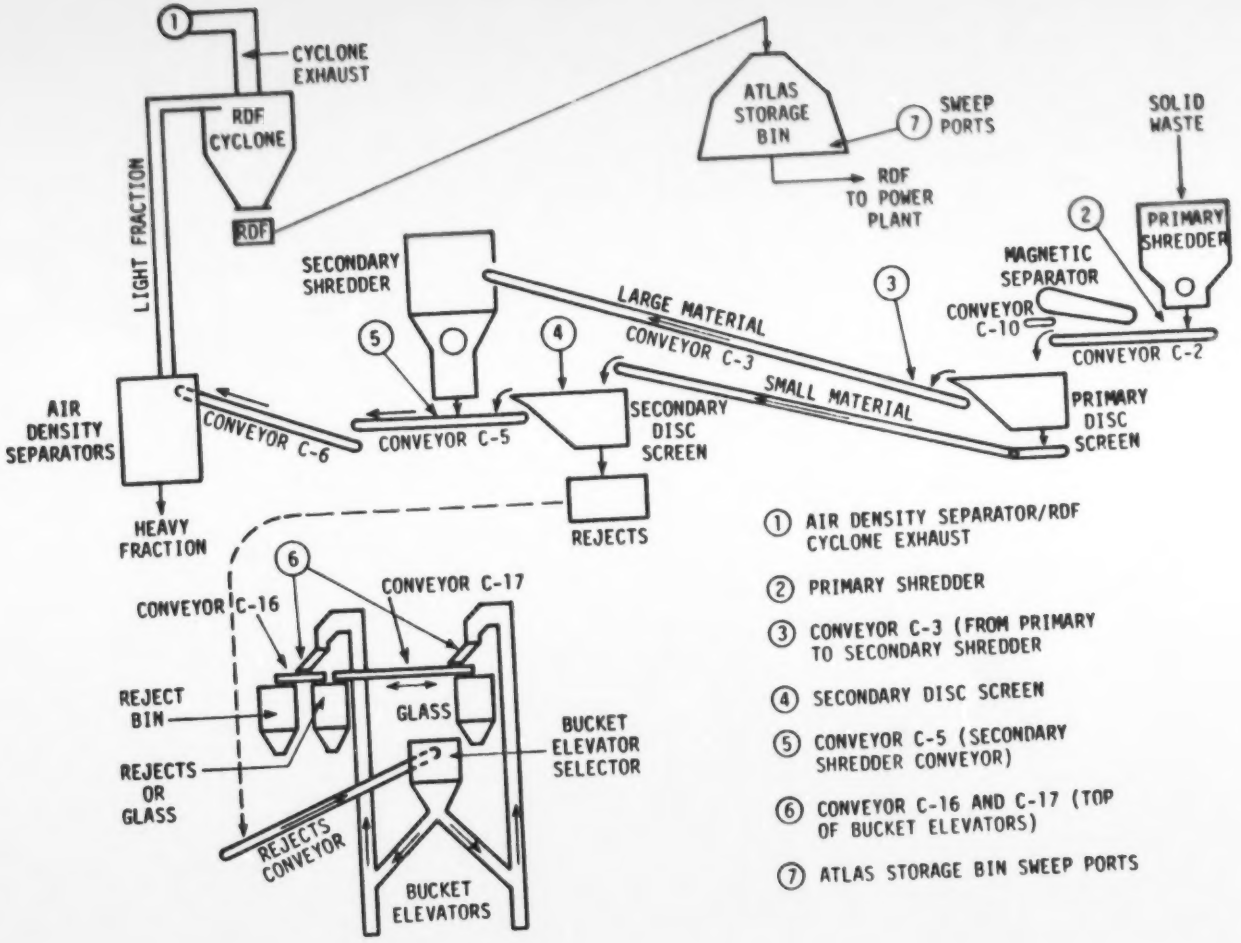

Figure 3-1. Sources from which particulate-laden air is ducted to the fabric filter

The sources and flow rates of particulate-laden air cleaned by the fabric filter are shown in Table 3-1.

TABLE 3-1. SOURCES AND FLOW RATES OF PARTICULATE-LADEN AIR[a]

Source	Flow rate, actual m^3/s (acfm)
Air density separator/RDF cyclone exhaust	11.8 (25,000)
Primary shredder	2.4 (5,000)
Conveyor C-3 (from primary to secondary shredder)	2.4 (5,000)[b]
Secondary disc screen	2.4 (5,000)
Conveyor C-5 (secondary shredder conveyor)	2.4 (5,000)
Conveyors C-16 and C-17 (top of bucket elevators)	0.5 (1,000)[b]
Atlas storage bin sweep ports	0.5 (1,000)[b]
	22.4 (47,000)

[a] All sources to the fabric filter were operating, except for the Atlas storage bin sweep ports.

[b] Estimated.

The conveyors, secondary disc screen, and shredders shown as sources in Table 3-1 are equipped with hoods at critical dusting points, especially transfer points. Dusting is controlled in these areas by pulling surrounding air into the hoods to prevent particulates from escaping into the in-plant ambient air. This air then mixes with air from other sources and is passed through the main fan. Up to this point, the particulate-laden air is

under negative pressure. After passing the main fan, the particulate-laden air is under positive pressure and is mixed with the air from the ADS.

The ADS is the single largest emission source supplying the fabric filter with dirty air. In this operation, air moves countercurrently and upward through the stream of falling refuse that has passed through the secondary shredder. The heavy fraction of refuse falls out the bottom of the ADS for further processing. The light fraction is fluidized by the upward stream of air and carried out the top of the ADS for removal in a cyclone. Once the light fraction (now RDF) is removed from the classifying air in the cyclone, the air is sent directly to the fabric filter for particulate removal.

SECTION 4

TEST PLAN

The test plan was designed to quantify particulate removal efficiency of the fabric filter controlling dust emissions from various point sources at the Ames resource recovery plant (see Section 3). The test plan evaluated this efficiency by collecting simultaneous inlet and outlet particulate loading data under normal operating conditions.

Particulate-laden air is routed to the fabric filter under positive pressure through the inlet duct. Because the fabric filter is located inside the plant, an outlet duct or stack is not necessary. The clean air exits the fabric filter directly through perforated flooring between the dust collection hoppers and through the "open-air" top. A single layer of polyethylene was placed on top of the floor to force all the exhaust out the top of the fabric filter. The doorway opening to the fabric filter was also sealed with polyethylene.

The test plan consisted of four test runs, for each of which one inlet sample and two simultaneous outlet samples were collected (see Appendix B on sampling methodology). The inlet to the fabric filter was tested by EPA Method 5. Isokinetic, integrated sampling was used while traversing the cross section of the inlet

duct. Particulate loading was determined from the front-half catch of the Method 5 source sampling train.

Outlet sampling was performed concurrently with the inlet Method 5 sampling. Although the fabric filter outlet is an emission source, the unconventional outflow configuration prevented sampling by Method 5. Instead, two portable hi-vol samplers were suspended from a movable cable at the exit of the fabric filter (see Figure 4-1). The two samplers were run simultaneously while traversing the cross section of the fabric filter outlet. Two sampling traverses were chosen because of the configuration of the outlet cross section. As the top view in Figure 4-1 shows, the left traverse sample represents air passing between the outside walls and adjacent inlet headers. The right traverse sample represents air from the center of the device, between the inlet headers. The final evaluation was based on the average of the particulate concentrations found in these two areas. Although outlet sampling was not under isokinetic conditions, flow rate was continuously measured and documented throughout each test run.

The appendices give further information about the testing. Appendix A provides the specifications of the fabric filter unit. Appendix B discusses the sampling and analytical methodology. Appendix C consists of computerized data calculations for inlet sampling conditions and hand-completed data sheets for outlet sampling. Appendix D describes the quality assurance procedures.

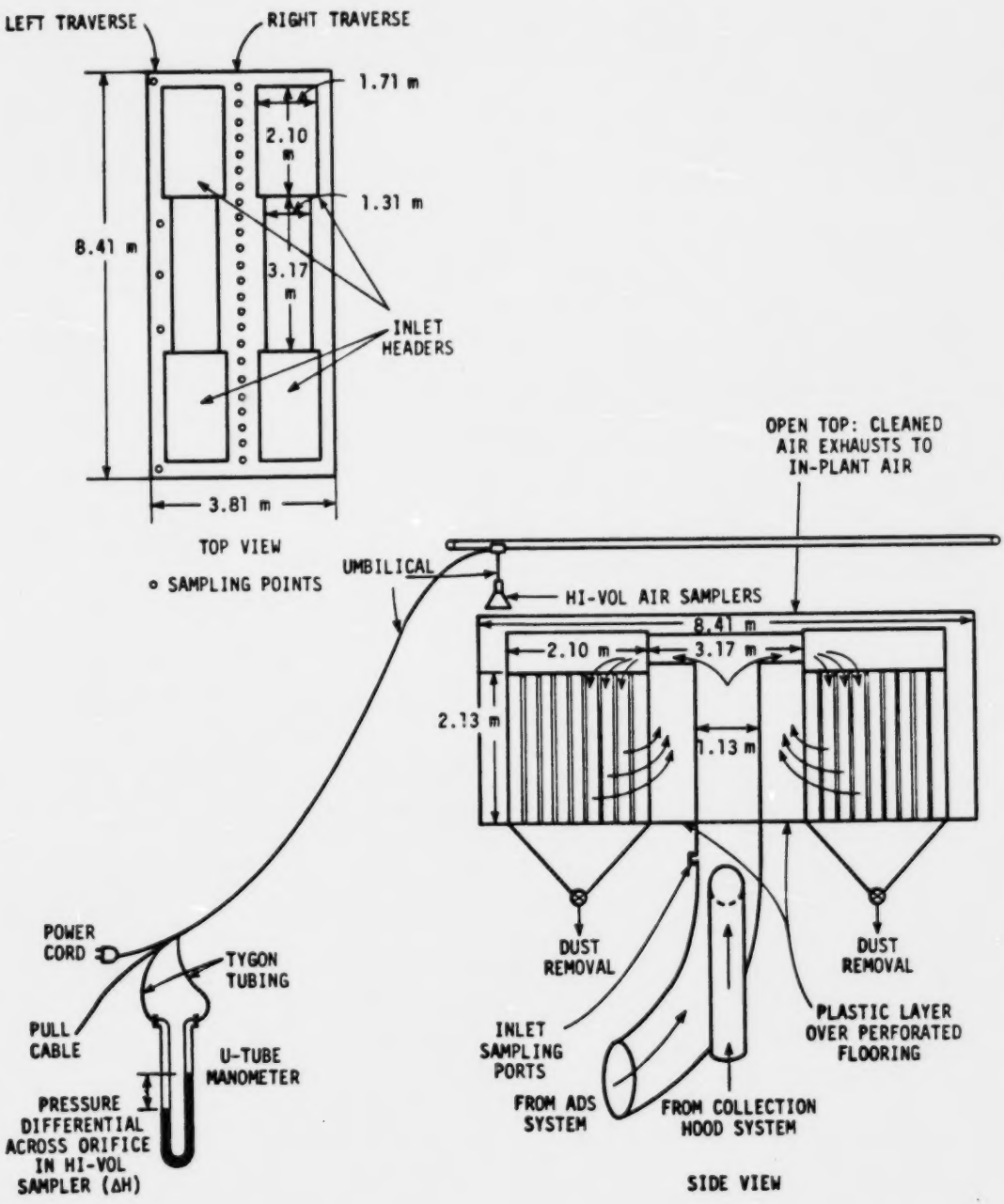

Figure 4-1. Fabric filter detail and sampling configuration.

SECTION 5

RESULTS AND RECOMMENDATIONS

The results of inlet particulate sampling are shown in Table 5-1. The results of Test Run B-4 have been eliminated from consideration in the final evaluation because of an unreasonably high moisture content reported (see inlet data sheets, Appendix C). Excluding Test Run B-4, inlet particulate concentration averaged 446 mg/dry standard m^3, with a range from 259 to 748 mg/dry standard m^3. The corresponding particulate mass flow rate averaged 32.3 kg/h and ranged from 19.5 to 52.6 kg/h.

The results of outlet particulate sampling are shown in Table 5-2. Each outlet test run is composed of two sample traverses, right and left. The final evaluation of performance is based on an average of the right and left traverse for each run. For all test runs, outlet particulate concentration averaged 11.9 mg/dry standard m^3, with a range from 8.63 to 18.6 mg/dry standard m^3. The average particulate emission rate from the fabric filter was 0.878 kg/h, with a range from 0.588 to 1.36 kg/h.

As indicated in Table 2-1, particulate removal efficiency ranged from 96.7 to 98.5 percent. Excluding Test Run B-4, the average particulate removal efficiency was 97.8 percent. Although this average may seem low when compared with the performance of other similar fabric filters, no attempts were made by the staff

TABLE 5-1. INLET PARTICULATE DATA[a]

Test run No.	Average temperature at inlet, °R	Actual volume of gas sampled, m^3 (ft^3)	Volume of gas sampled at standard conditions, m^3 (ft^3)	Total Particulate, mg	Particulate concentration, mg/dry std. m^3
B-1	555	0.984 (34.76)	0.942 (33.3)	704.6	748
B-2	557	1.13 (39.95)	1.06 (37.6)	275.0	259
B-3	557	1.15 (40.46)	1.07 (37.9)	353.9	331
B-4	558	1.09 (38.44)	1.03 (36.4)	731.2	710

[a] For all test runs, the barometric pressure was 760.0 mm (29.92 in.) Hg, the stack pressure was 766.6 mm (30.18 in.) Hg, and the sampling time was 48 min.

TABLE 5-2. OUTLET PARTICULATE DATA[a]

Test run No.[b]	Average ΔH,[c] cm (in.) H_2O	Average temperature at outlet, °R	Sampling flow rate, m^3/min (acfm)	Sampling time, min	Volume of gas sampled at standard conditions, m^3 (ft^3)	Total particulates, mg	Particulate concentration, mg/dry std. m^3
B-1R	12.7 (5.0)	557	1.07 (37.9)	48	48.7 (1720)	451.4	9.27
B-1L	10.4 (4.1)	557	0.977 (34.5)	40	37.1 (1310)	501.5	13.5
B-2R	16.0 (6.3)	555	1.21 (42.7)	48	55.2 (1950)	362.2	6.56
B-2L	15.5 (6.1)	555	1.19 (41.9)	45	50.7 (1790)	542.5	10.7
B-3R	18.5 (7.3)	550	1.31 (46.4)	48	60.6 (2140)	695.0	11.5
B-3L	21.8 (8.6)	550	1.45 (51.2)	45	62.6 (2210)	426.3	6.81
B-4R	19.1 (7.5)	554	1.33 (47.1)	48	61.2 (2160)	1292.3	21.1
B-4L	23.6 (9.3)	554	1.52 (53.8)	45	65.4 (2310)	1052.5	16.1

[a] For all test runs, the barometric pressure was 760.0 mm (29.92 in.) Hg.

[b] R designates right traverse and L designates left traverse.

[c] See Figure 4-1.

of the Ames plant or by PEDCo personnel to "fine-tune" the operation of the fabric filter. Bags were not replaced, and the unit was not cleaned or worked on just before testing. The values reported in this study thus indicate the performance of a device operating under routine circumstances.

Although the data show that the fabric filter at the Ames plant functions effectively, some improvements can be made. Bag shaking, a medium-energy cleaning mechanism, is currently used to remove dust that is prone to bridging and difficult to clean from the bags, and clogged bags remain a problem.

Use of a high-energy cleaning mechanism (such as air pulsing) might solve the problem, but such a mechanism must be implemented in the design phase of an installation. This solution might increase power consumption and shorten bag life, but it would decrease maintenance time.

The dust collection hoppers have contributed to bag clogging, especially around the perimeter of each section of bags. The location of the baghouse requires relatively shallow hopper side angles, which sometimes prevent dust from flowing freely from bags to hopper where the hopper side is very near the bottom of the bag. Steeper side angles, provided space is available, would alleviate the problem.

APPENDIX A

FABRIC FILTER SPECIFICATIONS

The fabric filter design specifications are listed below:

Fabric type: Woven cotton

Number of bags: 256, plus 8 special material handling bags

Total cloth area: 557.4 m^2 (6000 ft^2)

Design flow rate: 19.35 m^3/s (41,000 acfm)

Design air-to-cloth ratio: 0.035 m^3/s per m^2 (6.83 $acfm/ft^2$)

Measured inlet flow rate: 21.71 m^3/s (46,000 acfm) (average of B-1, B-2 and B-3)

Measured air-to-cloth ratio: 0.039 m^3/s per m^2 (7.67 $acfm/ft^2$)

Manufacturer: G.A. Kleissler Co., Trenton, New Jersey

APPENDIX B

SAMPLING AND ANALYTICAL METHODOLOGY

FABRIC FILTER INLET

Three sampling ports were installed in the inlet duct of the fabric filter downstream of the point of entry of all emission sources. The inlet duct was 1.12 by 0.84 m (44 by 33 in.). The sampling points are shown in Figure B-1. Each point was sampled for 1 minute, using the procedure described below.

The sampling and analysis program used for sampling the inlet followed the Method 5 procedures described in the Federal Register.*

Sampling Apparatus

The particulate sampling train used in these tests at the inlet to the fabric filter met design specifications established by the Federal EPA. Assembled by PEDCo personnel, it consisted of:

Nozzle--stainless steel (316) with sharp, tapered leading edge and accurately measured round opening.

Probe--Pyrex glass with a heating system capable of maintaining a minimum gas temperature of 121°C at the exit end during sampling.

Pitot tube--Type S pitot tube meeting all geometric standards outlined in Method 2 of the Federal Register* was attached to the sample probe to monitor stack gas velocity.

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

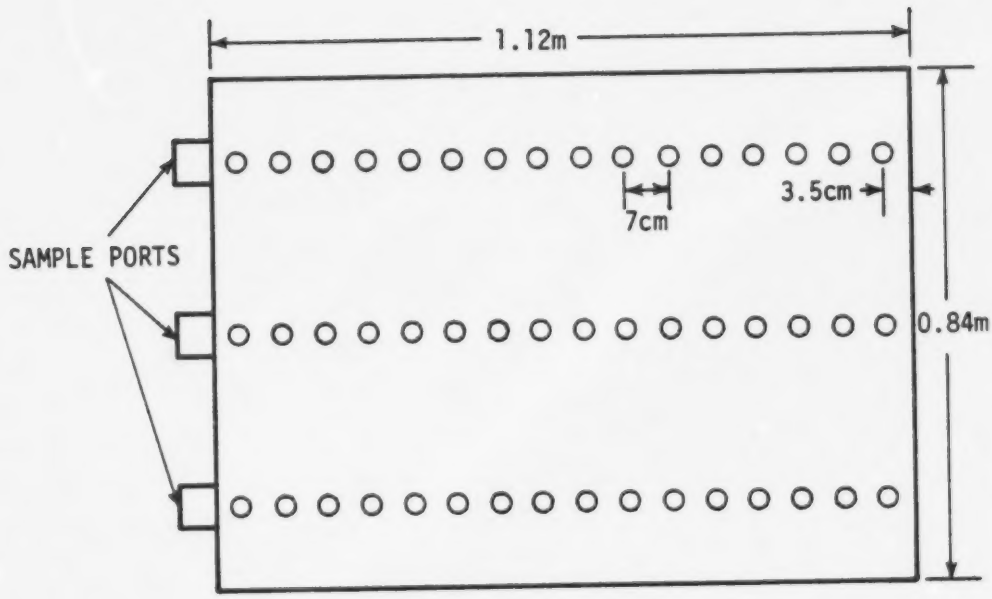

Figure B-1. Sampling points for fabric filter inlet.

Filter holder--Pyrex glass with heating system capable of maintaining a filter temperature of approximately 121°C.

Draft gauge--an inclined manometer made by Dwyer with a readability of 0.025 cm H_2O in the range from 0 to 2.54 cm.

Impingers--four impingers connected in series with glass ball joints; the first, third, and fourth impingers were of the Greenburg-Smith design, modified by replacing the tip with a glass tube (the inner diameter of which was 1.27 cm) extending to 1.27 cm from the bottom of the flask.

Metering system--vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within -15°C, dry gas meter with 2 percent accuracy, and related equipment to maintain an isokinetic sampling rate and to determine sample volume; the dry gas meter was made by Rockwell, and the fiber vane pump was made by Gast.

Barometer--Bourden tube type to measure atmospheric pressures to $\pm$0.254 cm Hg.

Sampling Procedure

After selection of the sampling site and the minimum number of traverse points, the stack pressure, temperature, moisture, and range of velocity head were measured according to procedures described in the Federal Register.*

Approximately 200 grams of silica gel were weighed in a sealed impinger prior to each test. Glass fiber filters (Gelman Type A, 7.62 cm in diameter) were desiccated for at least 24 hours and weighed to the nearest 0.1 mg on an analytical balance. Each of the first two impingers was filled with 100 ml of distilled water, the third impinger was left initially empty, and the impinger containing the silica gel was placed next in series. The train was set up with the probe as shown in Figure B-2.

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

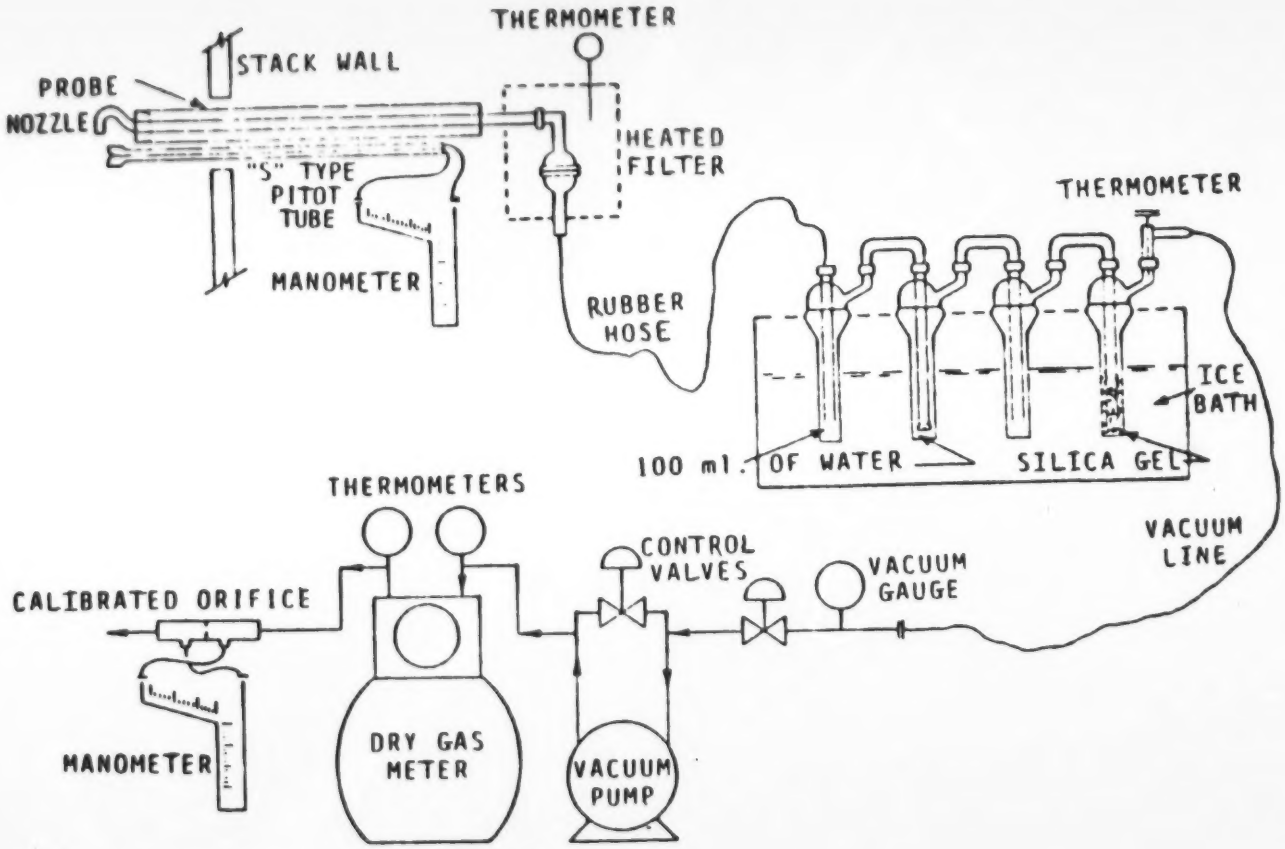

Figure B-2. Inlet source sampling train.

The sampling train was checked for leaks at the sampling site before each test run by plugging the inlet to the nozzle and pulling a 380 mm (15 in.) Hg vacuum. It was also checked for leaks at the conclusion of the test by plugging the inlet to the nozzle and pulling a vacuum equal to the greatest vacuum reached during the test run.

The pitot tube and lines were checked for leaks at the test site before and after each test run. The checks were made by blowing into the impact opening of the pitot tube until 8 or more cm inches of water were recorded on the manometer. The impact opening was then capped and held for 15 seconds to assure that it was free of leaks. The static-pressure side of the pitot tube was checked for leaks by the same procedure, except suction was used to obtain the 8 cm H_2O manometer reading. Crushed ice was placed around the impingers to keep the temperature of the gases leaving the last impinger at 20°C or less.

During sampling, stack gas and sampling train data were recorded at each sampling point and when significant changes in stack flow conditions occurred. Isokinetic sampling rates were set throughout the sampling period with the aid of a nomograph. All sampling data were recorded on the particulate field data sheets included in Appendix C.

Sample Recovery Procedure

The sampling train was moved carefully from the test site to the cleanup area. Samples of the acetone used in the sample

recovery were taken for use as blanks. The volume of water from the first three impingers was measured. Sample fractions were recovered as follows:

Container 1--the filter was removed from its holder and placed in a petri dish and sealed.

Container 2--loose particulate and acetone washings from all sample-exposed surfaces prior to the filter were placed in a glass jar, sealed, and labeled; particulate matter was removed from the probe with the aid of a brush and acetone rinsing. The liquid level was marked after the container was sealed.

Container 3--a minimum of 200 ml of acetone was taken for the blank analysis; the blank was obtained and treated in a similar manner as the acetone washing.

The silica gel from the fourth impinger was weighed and recorded with other pertinent data.

Analytical Procedures

The following procedures were used, as described in the Federal Register.*

Container 1--the filter and any loose particulate matter from this sample container were placed into a tared glass weighing dish, desiccated for 24 hours to a constant weight and weighed to the nearest 0.1 mg.

Container 2--the acetone washings were transferred to a tared beaker, evaporated to dryness at ambient temperature and pressure, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container 3--the acetone blank was transferred to a tared beaker and evaporated to dryness at ambient temperature and pressure; the blank was then desiccated for 24 hours to a constant weight and weighed to the nearest 0.1 mg.

The term constant weight means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever

* Federal Register, Vol. 42, No. 160, August 18, 1977.

is greater between two consecutive readings, with no less than 6 hours of desiccation between weighings.

FABRIC FILTER OUTLET

The sampling and analytical methods used for the outlet gas stream at the fabric filter were modifications of the high-volume method outlined in the Code of Federal Regulations, Title 40, Part 50.11, Appendix B, July 1, 1975.

Sampling Apparatus

The sampling equipment used in the tests at the outlet of the fabric filter met the specifications established by the Federal EPA and was assembled by PEDCo Environmental personnel. It included the following:

Sampler--consisted of three units: (1) the face plate and gasket, (2) the filter adapter assembly, and (3) the motor unit (Figure B-3). The sampler was capable of passing ambient air through an approximate 400-cm^2 area of a clean 20.3-by-25.4-cm (8-by-10-in.) glass-fiber filter at a rate of at least 1.13 m^3/min (40 ft^3/min); the motor was capable of continuous operation for 24 hours with input voltages ranging from 110 to 120 volts, 50 to 60 cycles a.c., equipped with a third wire safety ground; the housing for the motor unit kept the unit airtight and leak-free.

U-tube manometer--manometer marked in a suitable set of units, capable of measuring pressure to the needed centimeters of water.

Timer--a timepiece of known accuracy (i.e., not showing a loss or gain of 2 minutes per 24-hour period).

Sampling Procedure

After a preliminary site survey, the location of traverse lines and the minimum number of traverse points were determined (see Figure B-4). There were two traverse lines, sampled

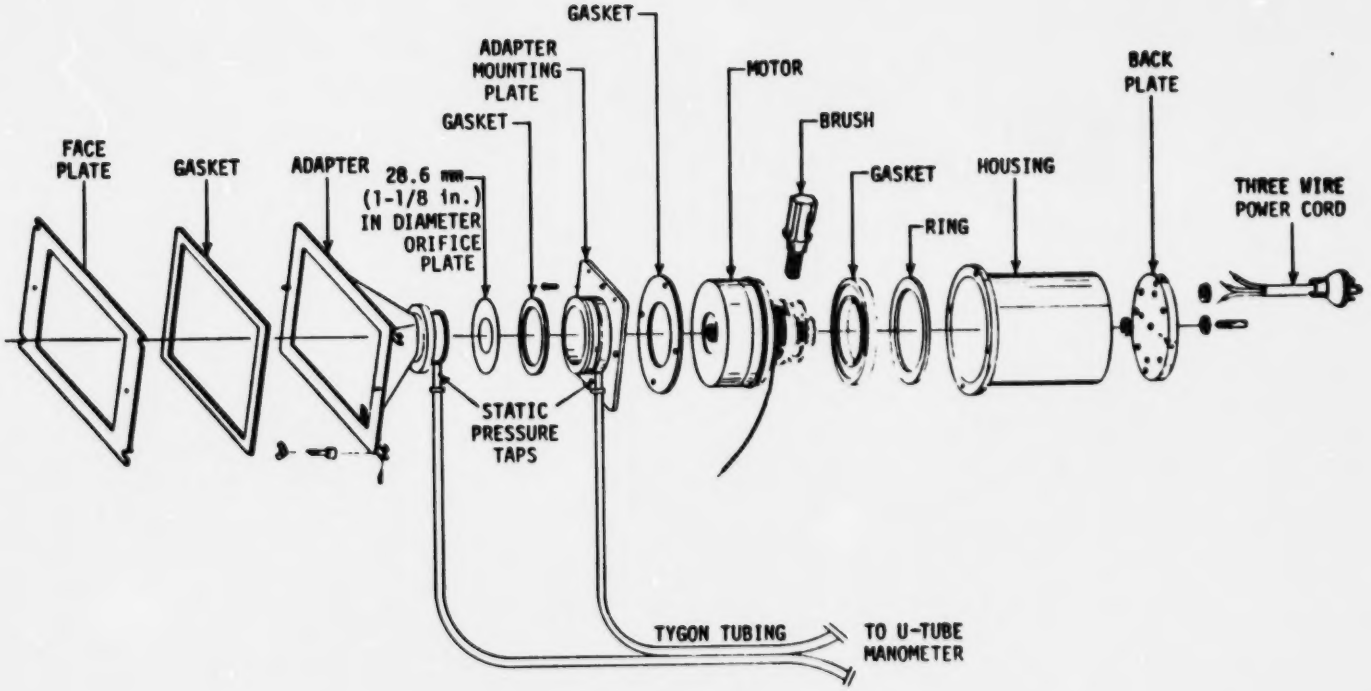

Figure B-3. Exploded view of high-volume sampler parts.

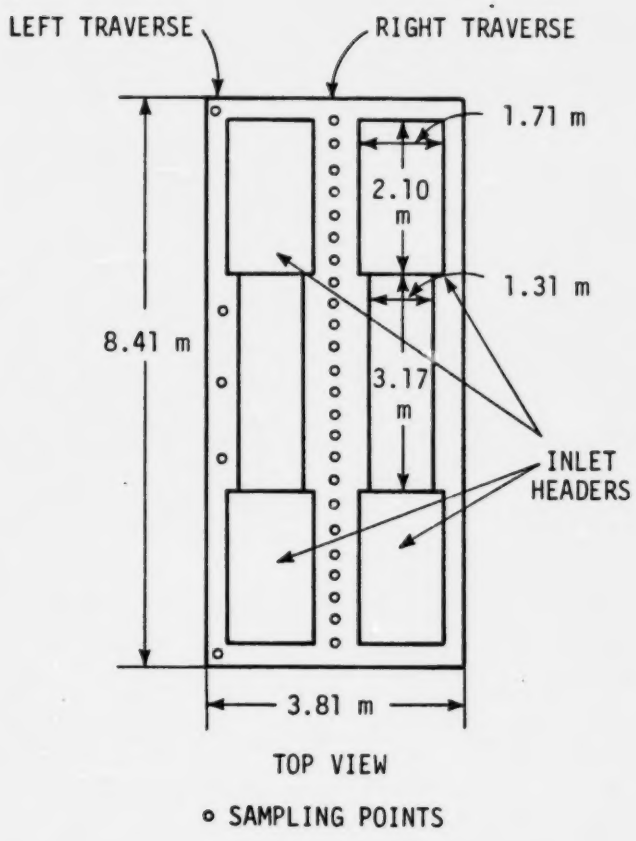

Figure B-4. Sampling location for fabric filter outlet.

simultaneously with separate high-volume samplers. One was designated right traverse, and the other was designated left traverse. The right traverse was sampled at 24 points for 2 minutes each. The left traverse was sampled at 5 points for 9 minutes each.

Each glass-fiber filter measured 20.3 by 25.4 cm (8 by 10 in.), was equilibrated for at least 24 hours at room temperature and less than 50 percent humidity, and was weighed to the nearest 0.1 mg on an analytical balance. The sampler was carefully assembled with a filter immediately before the time of sampling. The in-plant temperature and pressure were recorded.

During sampling, temperature and flow rate data were recorded at every traverse point on the particulate field data sheet (see Appendix C).

Sample Recovery Procedure

After the sampling run was completed, the filter-adapter assembly was carefully removed from each high-volume sampler. The holder was then wrapped with a plastic bag to help maintain sample integrity during transport to the sample cleanup area. Each filter was carefully recovered from the holder, folded twice (so that the exposed side of the filter was enclosed), and put into plastic zip-lock bags. The samples were carefully labeled with test run number, right or left traverse, filter number, date, time, and sampling personnel. All pertinent data were recorded.

Analytical Procedures

The filter and any loose particulate matter was equilibrated for 24 hours to a constant weight and weighed to the nearest 0.1 mg. The term constant weight means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater between two consecutive readings, with no less than 6 hours of desiccation between weighings.

APPENDIX C

QUALITY ASSURANCE PROCEDURES

An inherent requirement in the design and initiation of any monitoring program is a quality assurance plan to ensure the gathering of representative samples, adequate documentation, and accurate and precise lab analyses. A system of checks and techniques has been developed to achieve these results and was applied in the sampling and analytical methodology. The following quality assurance procedures were implemented:

All sampling and analytical equipment was calibrated, and periodic calibration checks were made.

Documentation of samples and of corresponding data was complete and accurate and independently checked.

Calculations were randomly checked.

SOURCE SAMPLING EQUIPMENT CALIBRATION

All of the equipment used was calibrated according to the procedures outlined in the publication entitled "Maintenance, Calibration, and Operation of Isokinetic Source-Sampling Equipment" (Office of Air Programs Publication APTD-0576).

The nozzles used in the source sampling train were calibrated by making three separate measurements with different inside diameters and calculating the average. If a deviation of more than 0.0051 cm was found, the nozzle was either discarded or reamed out and remeasured. A micrometer was used for measuring.

Figure D-1 shows the setup used before and after testing for calibration of the dry gas meter and orifice. A wet test meter with a capacity of 0.0566 m^3 and accuracy of $\pm$1 percent was used. The pump was run for approximately 15 minutes at an orifice manometer setting of 1.27 cm of water to heat up the pump and wet the interior surface of the wet test meter. The information required for the data sheet shown in Figure D-2 was gathered for the initial calibration, the ratio of accuracy of the wet test meter to the dry test meter was determined, and the pressure change across the orifice in the high-volume sampler was calculated.

A calibration check was made after testing on the meter box used during the test to check its accuracy against its last calibration check. This post-test calibration was required to be within $\pm$5 percent of the initial calibration. The initial calibration was performed as described in Publication APTD-0576. The post-test calibration was performed by the same method as the initial calibration. Three calibration runs were made with the average orifice setting obtained during each test run and with the vacuum set at the average value obtained during each test run. All three runs were within the range of $\pm$5 percent allowed by the Federal Register.*

HIGH-VOLUME SAMPLER CALIBRATION

The orifice that was used to measure the flow rate of the high-volume sampler was calibrated with a Rootsmeter. Figure D-3

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* Federal Register, Vol. 42, No. 160, August 18, 1977.

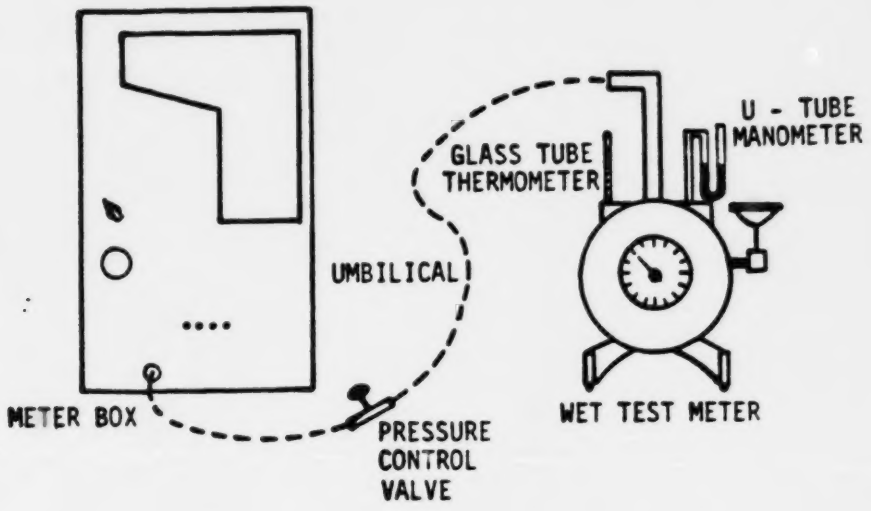

Figure C-1. Calibration setup.

DATE_____ METER BOX NO._____

BAROMETRIC PRESSURE, P_b = _____in. Hg. DRY GAS METER NO._____

Orifice manometer setting ΔH in. H_2O	Gas volume wet test meter V_w, ft_3	Gas volume dry gas meter V_d, ft_3	Wet test meter t_w, °F	Dry gas meter Inlet t_{di}, °F	Dry gas meter outlet t_{do}, °F	Dry gas meter Average t_d, °F	Time θ, min	Y	ΔHθ
0.5	5								
1.0	5								
1.5	10								
2.0	10								
3.0	10								
4.0	10								

Average _____

ΔH	$\frac{\Delta H}{13.6}$	Y $\frac{V_w P_b (t_d + 400)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$	ΔHθ $\frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
1.5	0.110		
2.0	0.147		
3.0	0.221		
4.0	0.294		

Y = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01
ΔHθ = Orifice of pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in H_2). Tolerance = +0.15.

Figure C-2. Calibration data sheet.

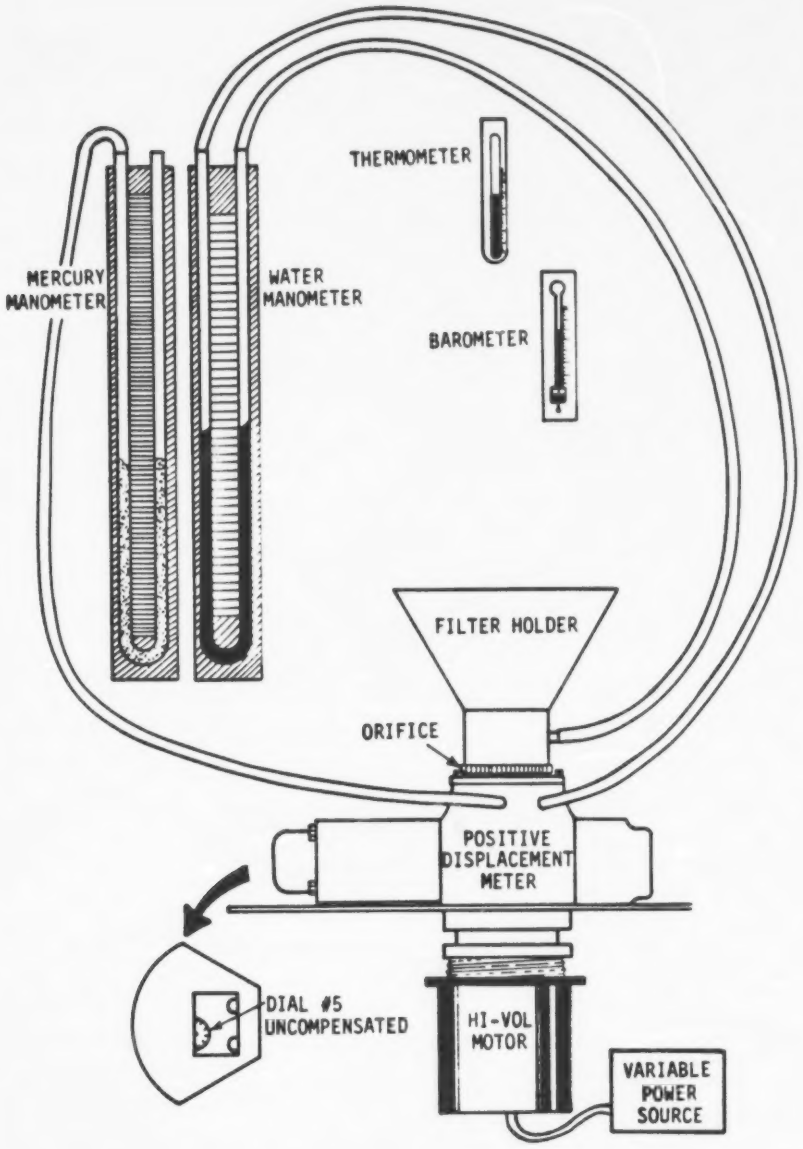

Figure C-3. Orifice calibration setup.

shows the calibration equipment and setup used. Figure D-4 shows the calibration curve from which flow rate was calculated for pressure differentials across the orifice of less than 25.4 cm (10 in.) H_2O. A calibration curve was generated by varying the flow rate through the positive displacement meter and measuring flow rate as a function of pressure change across the orifice.

ANALYSIS EQUIPMENT CALIBRATION

The analytical balance calibration was verified with a standard weight covering the weight range normally encountered in weighing filters. The standard weight was required to weigh within $\pm$0.5 mg of its stated value.

The relative humidity indicator used for monitoring the conditioning environment for weighing filters was checked against a wet-bulb/dry-bulb psychrometer. A two-point calibration was made.

DOCUMENTATION OF SAMPLES

All samples and corresponding data were documented with a run number. This number along with all pertinent data was recorded on samples and data forms (see Appendix C). All forms were reviewed by the field supervisor to assure completeness and accurate recordkeeping.

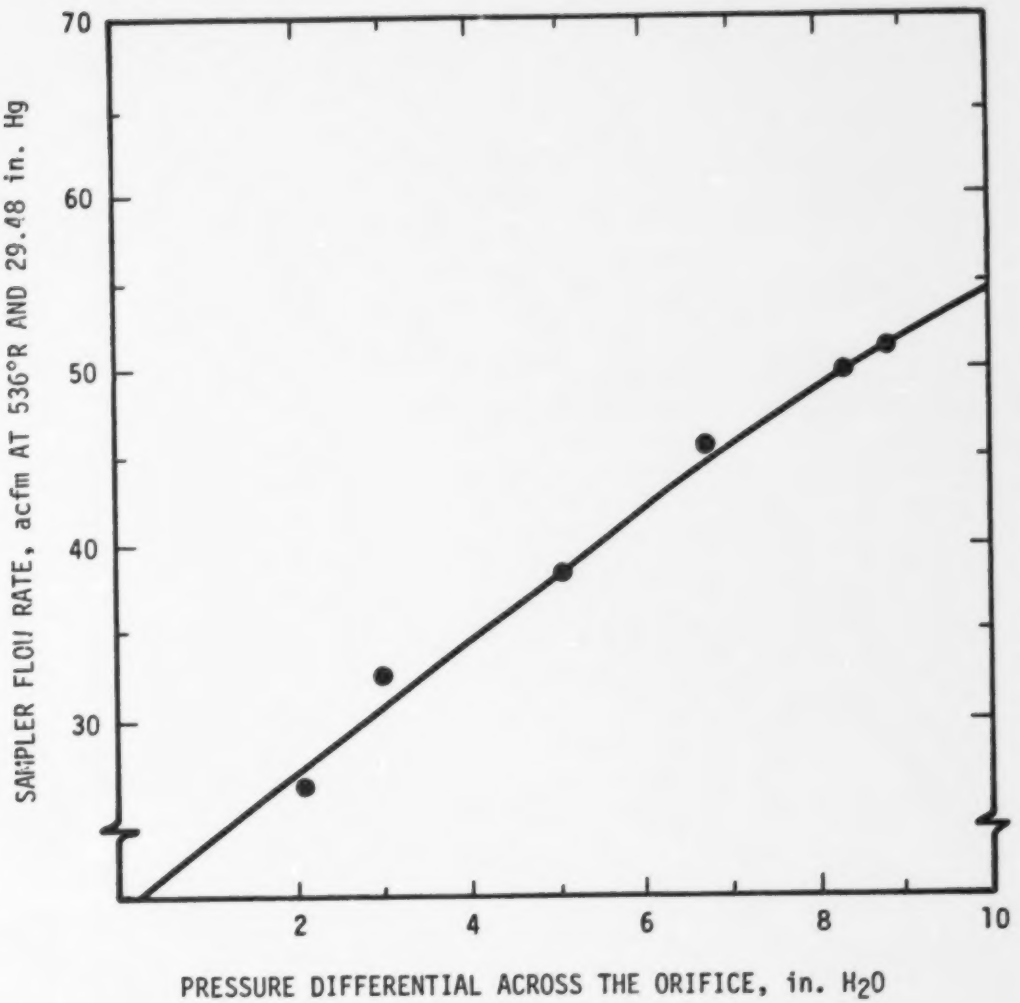

Figure C-4. High-volume sampler calibration results.

AUDIT OF CALCULATIONS

All data were audited independently for errors in transcription or miscalculation. This review assures data integrity throughout the analytical process. A copy of the computer printout is available in Appendix C, which gives all calculations for inlet samples.

Outlet data were received from the lab, reviewed, and tabulated.